ANALYSIS OF MIMO SYSTEM OVER A COMPOSITE FADING CHANNEL

SYNOPSIS

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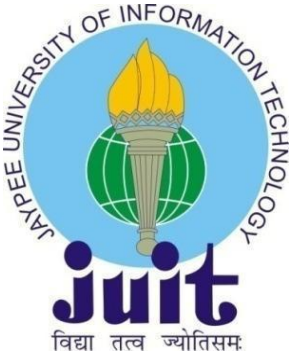

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CONTENTS

1. INTRODUCTION
2. OBJECTIVES
   2.1 Analyze and improve the multiple-input multiple-output (MIMO) system performance using spatial diversity and spatial multiplexing in multipath and a composite fading scenario.
   2.2 Analyze the MIMO system performance in low SNR regime.
   2.3 Analyze the MIMO system performance using antenna selection.
   2.4 Analyze the system performance in composite fading scenario subject to generalized noise i.e. additive white generalized Gaussian noise (AWGGN) with simple and efficient detection.
3. CONCLUSION AND FUTURE SCOPE

REFERENCES

LIST OF PUBLICATIONS

1. INTRODUCTION

Multiple-input and multiple-output (MIMO) is one of the emerging technique in wireless communication to achieve reliability and high data rate. An increased reliability is met by using the spatial diversity techniques, which include transmit and receive diversity. Consequently, the high data rate is achieved by using spatial multiplexing. To achieve the full transmit diversity, orthogonal space-time block codes (OSTBCs) have been employed in MIMO systems while allowing a simple maximum likelihood decoding algorithm [1]. The receive diversity is realized by maximal ratio combining (MRC) technique which provides the most significant improvement in error rate performance by maximising output signal-to-noise ratio (SNR) [2]. A tradeoff occurs between spatial diversity and spatial multiplexing (SM) for multiple access channels [3]. The spatial diversity provides the simple signal detection but at the cost of reduced capacity [4]. The improved capacity can be achieved by using SM, however, spatial demultiplexing is a complicated task. Thus, the current research in MIMO wireless communication mainly focuses on the development of signal detection techniques. The minimum mean square error-ordered successive interference cancellation (MMSE-OSIC) detection has been used to improve the system performance with less complexity, but it does not give the optimal performance. To achieve the optimal performance, maximum likelihood (ML) detection technique have been employed at the cost of high computational complexity [5, 6]. Subsequently, MMSE-OSIC with candidates (MMSE-OSIC^2) detection has been proposed which selects a number of candidate vectors at each layer unlike traditional MMSE-OSIC [7]. MMSE-OSIC^2 gives a near ML performance with a complexity level comparable to that of traditional MMSE-OSIC.

Most of the detection techniques have been implemented to improve the system performance in high SNR regime. Since many locations in the geometry lie on the edge of their cells, therefore, apart from operating at high SNR, users frequently work at low SNR. In such conditions, the system performance evaluation at low SNR is imperative to the system designers even in the severe fading environment.

In several practical wireless environments, multipath fading and shadowing appear at the same time which leads to a composite fading. A newly-fangled composite channel model i.e. Weibull-gamma (WG) has been proposed which becomes an emerging area of interest due to its analytical tractability and experimental validity [8]. In WG channel model, Weibull fading considers the effects of radar clutters and different indoor/outdoor scenarios, while, the gamma model considers the shadowing effects. In [9], MIMO systems namely SM with the optimal detector, SM with the

MMSE detector and OSTBC have been developed to evaluate performance at low SNR over Weibull fading channel. However, the impact of shadowing has not been analyzed. Some performance analysis on the basis of capacity and error rate has been presented over WG channel [8, 10, 11] but it has been explored to a lesser extent. Therefore, the same is considered in our work.

One of the problems with multiple antenna systems is the requirement of a large number of non-economical radio frequency (RF) modules which enhance the cost of the system. Thus, antenna selection (AS) technique has been recommended as the most suitable solution for cost reduction of multiple RF modules. Consequently, it enhances the system performance due to channel state information (CSI) availability at the transmitter side [12].

Generally, a multipath fading or a composite fading scenario is considered in the presence of additive white Gaussian noise (AWGN) to evaluate the system performance for both higher and lower modulation orders [13]. However, the deviation of actual noise is possible, and we require a generic noise model. The generalized Gaussian distribution (GGD) is the subject of interest to model different noise effects such as impulsive, gamma, Gaussian and Laplacian [14].

In the proposed work, initially, the MIMO system performance has been analyzed under Weibull fading. Then, a composite WG fading channel is considered for the MIMO system analysis and its performance improvement. The amount of fading is a significant measure to define the severity of fading, and therefore, it is analyzed for WG fading in detail. OSTBC and MRC techniques are considered to enhance the symbol error rate (SER) performance of MIMO system. We have compared the SER performance of MIMO system with three detection techniques namely MMSE-OSIC, ML, and efficient as well as less complex MMSE-OSIC^2. Further, we have analyzed the capacity performance in low SNR regime using optimal detectors and simple MMSE detectors in WG fading scenario. For further improvement in the MIMO-OSTBC system performance, we have used antenna selection (AS) technique.

To the best of our knowledge, the MIMO system performance has not been evaluated for composite WG fading channel with the consideration of generalized noise and hence, we have proposed this work. To improve the MIMO system performance in WG fading and additive white generalized Gaussian noise (AWGGN), we considered SM with previously mentioned MMSE-OSIC, ML and MMSE-OSIC^2 detection techniques. Comparing all three, MMSE-OSIC^2 has been shown to be advantageous in giving a near optimal performance at a reduced complexity. Also, the variations of fading and shadowing parameters are also illustrated.

2. OBJECTIVES

2.1 Analyze and improve the MIMO system performance using spatial diversity and spatial multiplexing in multipath and a composite fading scenario.

- *Error Rate Analysis using OSTBC and MRC under Weibull and a Composite Weibull-Gamma fading*

The motivation behind this objective includes the work proposed in [3-9]. Consider a MIMO system having $N_r \times N_t$ antennas, where, N_t and N_r denote a number of transmit and receive antennas respectively with complex channel matrix H. In H, each element of channel is independent and identically distributed (i.i.d.) Gaussian random variables with zero mean and N_0 variance. Total transmit energy at each time interval is represented by E_s, $\mathcal{N}$ is receiver noise and its coefficients modeled as i.i.d. random variables. Initially, we have considered H as a Weibull fading channel [15, 16].

OSTBC and MRC diversity techniques have been employed to enhance the system performance. In space-time coded MIMO systems, the mapping is performed by converting a number of bits into symbols [12]. For transmitting b number of bits, modulation techniques such as BPSK, QPSK and 16-QAM are used which map every b bits to one symbol from a constellation with $2b$ symbols. A simple OSTBC has been considered which consists two transmit antennas and one receive antenna. The transmitter picks two symbols from constellation using a block of $2b$ bits, those are transmitted from antenna one and two. On the other hand, to achieve the best performance, the received signals in the different antennas is combined by MRC technique that considers one transmit and two receive antennas, however, computational burden at the receiver side increases which does not occur using OSTBC.

The capacity and symbol error rate (SER) are significant measures to evaluate the MIMO system performance. In [17], capacity performance has been evaluated, although, we have analyzed the SER performance over Weibull fading channel. As the value of Weibull fading parameter β increases, severity of fading reduces which improves the system's SER performance. The high data rate is achieved through higher order modulation, although, they are more sensitive to noise and interference than lower order modulation. It is justified by the simulation results of Fig. 1(a) and Fig. 1(b). Also, MRC gives 3dB improved SER performance compared to OSTBC. At $\beta = 2$, Weibull distribution is transformed into Rayleigh distribution and $\beta = 1$ converts Weibull distribution into exponential distribution.

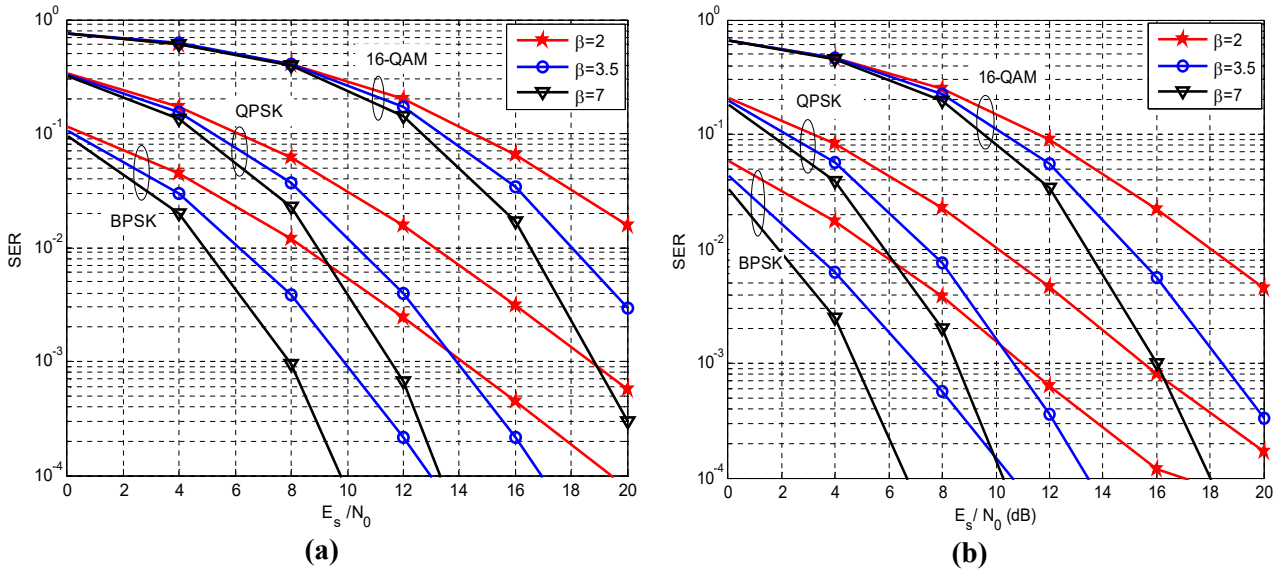

Fig. 1 SER using BPSK, QPSK and 16-QAM over Weibull fading channel for β= 2, 3.5 and 7 **(a)** OSTBC ($N_r = 1, N_t = 2$) **(b)** MRC ($N_r = 2, N_t = 1$)

Further, a composite Weibull-gamma (WG) fading channel is considered to model the effects of multipath fading and shadowing. Weibull and gamma random variables are independent of each other. For β = 2, it follows *K* or Rayleigh-lognormal distribution. Here, β denotes fading and m denotes shadowing parameter. For β = 2, $m \to \infty$, it approaches Rayleigh distribution and for $\beta \to \infty$, $m \to \infty$, it approaches AWGN distribution [18].

For a particular channel model, the severity of fading or the degree of fading experienced at the output of a MIMO system can be determined by AF [19]. In Fig. 2, AF is shown for different values of β in terms of m. AF decreases exponentially as the value of β and/or m increases. The channel performance is degraded for small values of m and β i.e., $m \in$ [0, 1] and $\beta \in$ [0, 1.5].

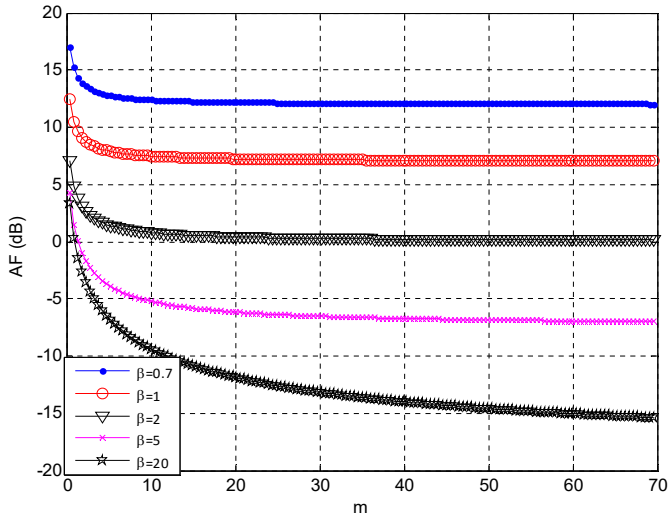

Fig. 2 The amount of fading (AF) for WG fading

After a certain limit, AF does not change with both the fading parameters (m, β) and attains a constant value. At m =1, AF is 15.13dB, and 0.124dB when β is 0.7 and 20 respectively. Numerically, 99.18 % reduction in AF is possible due to high β.

In [20], error rate performance has been evaluated for MIMO-OSTBC over a composite generalized-*K* (*GK*) channel. Moreover, WG is an alternative to *GK*, and we have considered both the OSTBC and MRC to evaluate the MIMO system performance. Fig. 3(a) shows the SER for MIMO-OSTBC with numerous values of β and m using 16-QAM. SER improves with the increase in E_s/N_0. Also, for higher values of β and m with a fixed E_s/N_0, SER performance increases. Consequently, improved SER is achieved by increasing N_t from 2 to 4.

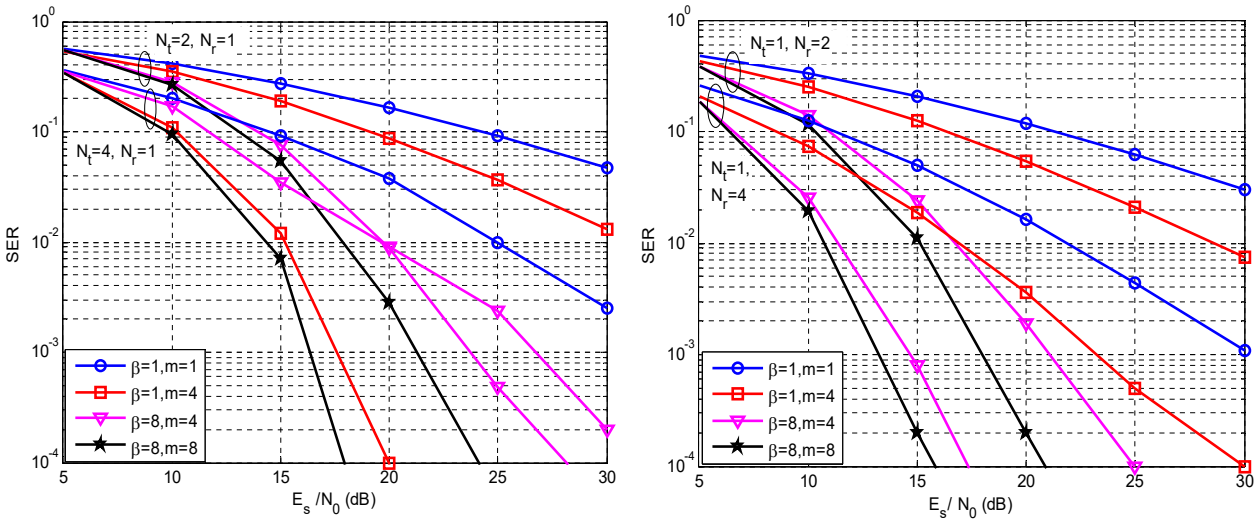

Fig. 3 SER for MIMO systems using 16-QAM over WG fading channel **(a)** OSTBC($N_r = 1$ and $N_t = 2,4$) **(b)** MRC ($N_r = 2,4$ and $N_t = 1$)

Multipath is highly accountable to degrade the wireless system performance. The impact of shadowing also reduces the error rate performance of the wireless system and hence, reduced shadowing effect can be observed by high values of m. Note that the WG channel matrix is created by the product of each entry of Weibull and gamma random variable. In Fig. 3(b), SER performance of MIMO-MRC system is evaluated with the same configurations and parameters as considered for OSTBC. Again, MRC gives 3dB improved SER performance compared to that of OSTBC in WG fading scenario.

- *SER Analysis using MMSE-OSIC, ML and MMSE-OSIC^2 detection over Weibull-Gamma fading channel*

After applying spatial diversity, we prefer spatial multiplexing to increase the data rate, however, we require an efficient detection technique for spatial demultiplexing at the receiver. Thus,

MMSE-OSIC, ML and MMSE-OSIC^2 detection techniques are considered to improve the error rate performance of MIMO system. The MMSE-OSIC detector contains a number of parallel data streams in which detected signal components are successively cancelled from the received signal at each stage/layer. Fig. 4(a) shows the SER performance of the first layer ($i = 1$) with MMSE-OSIC detection which is based on signal to interference plus noise ratio (SINR) ordering. The SER performance is analyzed for $N_t = N_r = 2$ under WG fading scenario, where, arbitrarily values of β and m are chosen. The parameters considered for all simulation are identical. Fig. 4(a) and Fig. 4(b) illustrate that less SNR is required in ML detection compared to that of MMSE-OSIC detection. For higher values of β and m, error performance is improved.

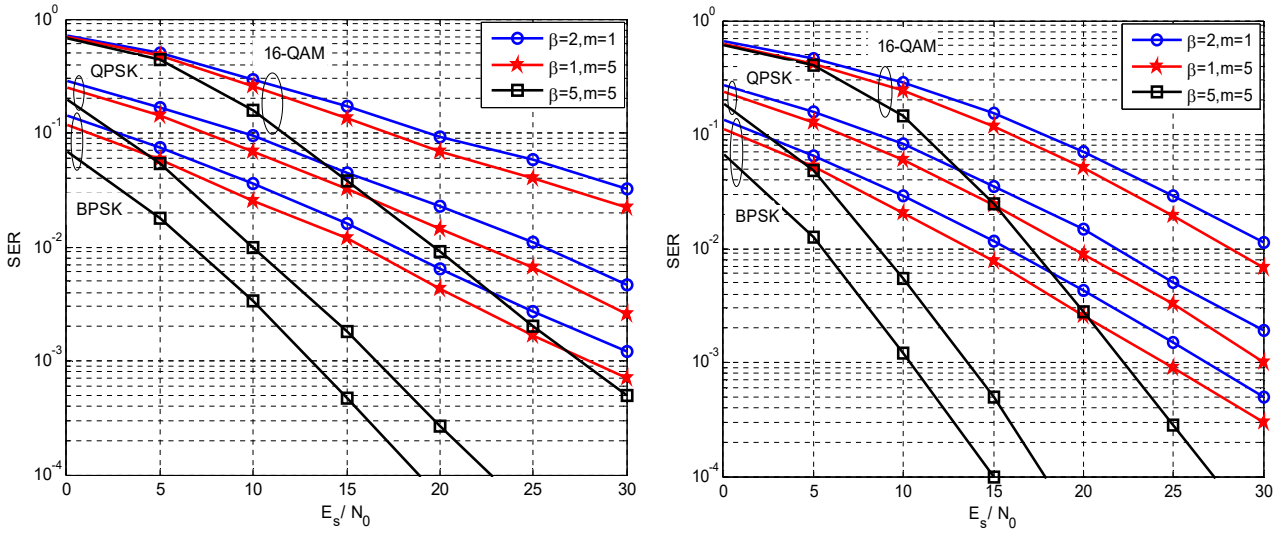

Fig. 4 SER of SM-MIMO system for BPSK, QPSK and 16-QAM over WG fading channel when $N_r = 2, N_t = 2$ **(a)** MMSE-OSIC detection **(b)** ML detection

In ML metric computation, number of required multiplication is 4, and the measured complexity is $|C_p|^2 \times 4$ for $N_r = N_t = 2$ where C_p is number of constellation points. Thus, total number of required multiplications in BPSK, QPSK and 16-QAM are 16, 64 and 1024 respectively using ML. In MMSE-OSIC, a number of multiplications performed are 367 and number of divisions are 14 for 16-QAM. The number of multiplication reduced to 53 and the number of division reduced to 4 in QPSK, however, the number of multiplication further reduced to 26 and division reduced to 2 in BPSK. The number of complex operations is greatly reduced in higher order modulation i.e. 16-QAM as compared to lower order modulation i.e. BPSK.

In MMSE-OSIC^2 detection process, a set of candidates is selected for each layer. N_t stages are considered in MMSE-OSIC^2 detection like MMSE-OSIC. In this detection, M candidate vectors

of length N_t are selected at N_t stages. To facilitate the detail of this process, we assume the optimal ordering of N_t and it is based on the channel matrix $\|h_r\|^2, r = i, i+1, \ldots . . N_t$. Accordingly, $\mathcal{M}$ selected candidates of matrix size $N_t \times 1$ are measured. Also, temporary vector $\mathcal{M} \times |C_P|$ of length N_t are generated. After that, $\mathcal{M}$ candidate vector of length N_t is selected. Subsequently, truncation is obtained in $\mathcal{M}$ candidate vectors of length i. A near-optimal performance can be achieved with less complexity level with MMSE-OSIC^2 detection technique. In this technique, the complexity level is comparable to traditional MMSE-OSIC. Also, MMSE-OSIC^2 detection constructively generates log likelihood ratio (LLR) values. Therefore, this detection technique gives conformity between improved performance and an acceptable level of complexity. Only at the high SNR, SER performance is slightly reduced. It is determined that the first layer approximates a full diversity order as ML in stage 1 (i=1). The complexity is measured in terms of number of addition, multiplication and division operations for implementing hardware.

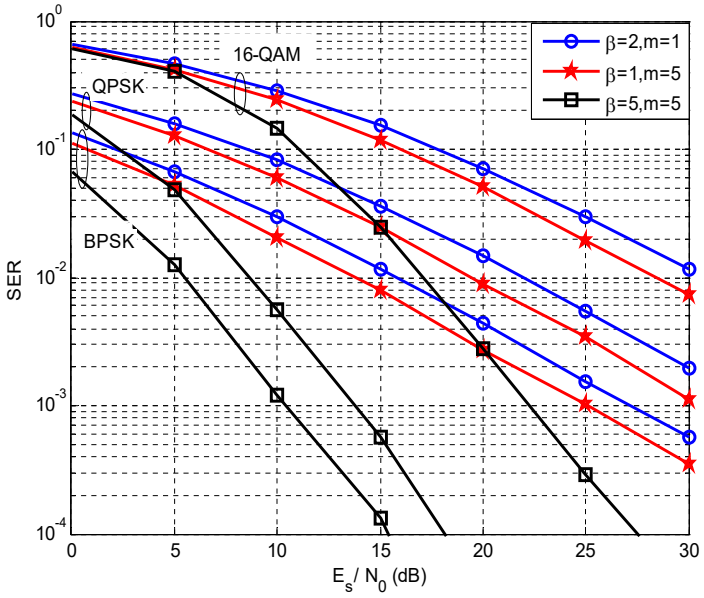

Fig. 5 SER of SM-MIMO system for BPSK, QPSK and 16-QAM using MMSE-OSIC^2 detection over WG fading channel for $\mathcal{M}$=1 and $N_r = 2, N_t = 2$

Total 10+2×$\mathcal{M}$, 28+4×$\mathcal{M}$ and 183+8×7×$\mathcal{M}$ multiplications are required for BPSK, QPSK and 16-QAM respectively. Two divisions are required for each modulation format. It is observed from the simulation results of Fig. 4(a), Fig. 4(b) and Fig. 5 that at large values of m, error performance is highly improved as compared to large value of β. For $\mathcal{M}$=1, a number of multiplications are 239 using 16-QAM. Consequently, 32 multiplications and 2 divisions are required using QPSK. For BPSK, a number of multiplications are 12 and division is 1. We have analyzed the system

performance by taking receiver SNR from 0dB to maximum 30dB. However, at low SNR, system performance improvement is also an issue which is analyzed in our next objective, as mentioned below.

2.2 Analyze the MIMO system performance in low SNR regime over WG fading channel

- *Capacity of MIMO system using MMSE and optimal detection*

It is desirable to obtain the improved data rate in low SNR as most of the users receive less than 0dB power in 40% of the geographical area and 10dB power in less than 10% area. According to [21], minimization of energy per information bit E_b governs a trade-off between bandwidth and power of the communication channels in wideband regime which is desirable for efficient signal communication. Also, normalized energy per information bit (E_b/N_0) is preferred over per-symbol SNR in the measurement of MIMO system performance precisely at low SNR over distinct fading channels. In MIMO systems, figure of merit depends on E_b/N_0 instead of SNR. In low SNR regime, the channel capacity analysis in terms of per symbol gives misguiding outcomes and hence capacity is defined in terms of minimum energy per information bit ($E_b/N_{0_{min}}$) [22].

We evaluated the capacity performance of SM MIMO with the optimal and MMSE detectors at low SNR. $E_b/N_{0_{min}}$ and wideband slope (S_0) are important parameters to convey any positive rate of data reliably and to analyze the capacity of MIMO system at low SNR.

Firstly, we use optimal detectors for analyzing the MIMO system performance in low SNR regime. Using SM optimal detectors, the wideband slope $S_0^{optimal}$ is lower bounded ($\beta \to 0$) and upper bounded ($\beta \to \infty$) as $0 \leq S_0^{optimal} \leq \frac{2N_tN_r}{N_t+N_r-1}$. Nevertheless, $E_b/N_{0_{min}}$ is reduced by increasing N_r because a higher number of receive antennas need more power as mentioned in [22]. The parameters chosen for K fading, and Rayleigh fading are $\beta = 2,$ and $\beta = 2, m \to \infty$ respectively.

In Fig. 6, the effects of low and high multipath fading are considered for $\beta = 20$ and 2 respectively in the presence of light shadowing (m =70) and heavy shadowing ($m = 1$). In light shadowing environment, i.e. for $\beta = 2$, Rayleigh fading is observed. In addition, the capacity for the special cases (i.e.,≈Rayleigh and K-fading) of GK fading in [23] approaches both the special cases of WG fading. For light shadowing (when m is large), the impact of shadowing on wideband slope is negligible.

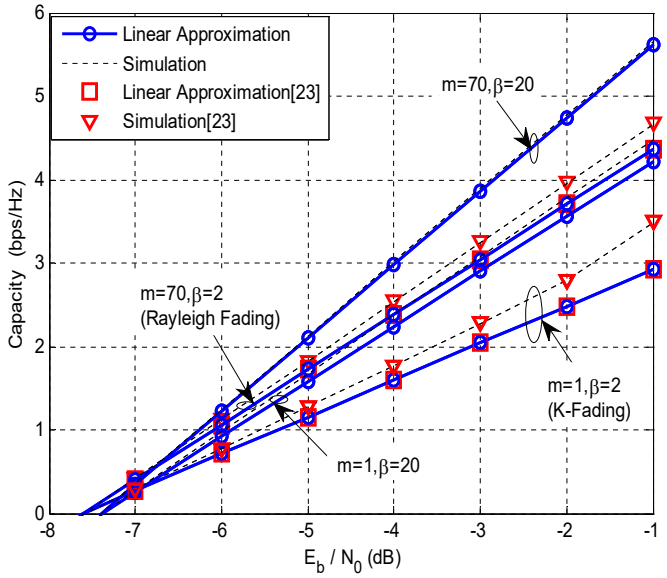

Fig. 6 Capacity of SM MIMO system with optimal detector over WG fading channels for different m and β when $N_t = N_r = 2$.

After that, we have used SM MIMO systems with MMSE detectors ($N_r \geq N_t$) to effort in low SNR.

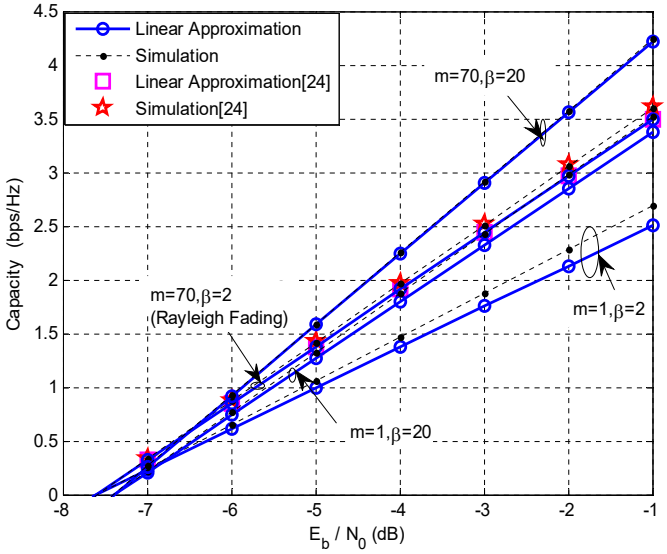

Fig. 7 Capacity of SM MIMO system with MMSE detector over WG fading channels for different m and β when $N_t = N_r = 2$.

We have characterized the linear approximation for capacity presented in [23] using optimal and MMSE detection over WG fading channel. Due to same $E_b/N_{0_{min}}$ for both optimal and MMSE detectors, optimal detection is realizable through MMSE detectors and S_0 gives suboptimal detection. Here, m = 1 shows the severe shadowing effect and consequent reduction in S_0 which is depicted in Fig. 7. Our linear results are most suited to simulation results. For a fair comparison,

we have compared our result with the results of [24] under a special case (i.e., Rayleigh fading) of WG fading except we considered shadowing effect. SM-MMSE offers performance with a high data rate keeping the complexity low. Here, CSI is known to the receiver only. If CSI is available at the transmitter side, MIMO system performance can further be improved by using antenna selection technique which helps to reduce the hardware cost of the system. In our next objective, we discuss on the implementation of such technique.

2.3 Analyze MIMO system performance using Antenna Selection over WG fading channel

- *BER Analysis with OSTBC*

Antenna selection technique is used for the error rate performance when CSI is known to the transmitter. The effective channel is characterized by L columns after selecting L antennas from N_t transmit antennas of $H \in \mathbb{C}^{N_r \times N_t}$. The index $\mathcal{J}_l$ is considered for the l^{th} selected column, $l = 1,2 \ldots . L$. The subsequent effective channel is modeled as $H_{(\mathcal{J}_1,\mathcal{J}_2,\ldots.\mathcal{J}_L)} \in \mathbb{C}^{N_r \times L}$. The mapping of spatially-multiplexed or space-time coded stream into L selected antennas is given as $s \in \mathbb{C}^{L \times 1}$. Transmit antennas are selected to reduce the error probability. For $H_{(\mathcal{J}_1,\mathcal{J}_2,\ldots.\mathcal{J}_L)}$ with L columns of H chosen, an upper bounded pairwise error probability for OSTBC is represented in [12].

The antennas subsequent to high column norms are chosen to reduce the error rate. The average received SNR with L selected antennas of $(\mathcal{J}_l)_{l=1}^{L}$ are determined. Then, the antennas with the maximum received SNR are chosen. The indices $\left(\mathcal{J}_1{}^o, \mathcal{J}_2{}^0, \ldots . \mathcal{J}_L{}^0\right)$ with the maximum L column norms of H are considered.

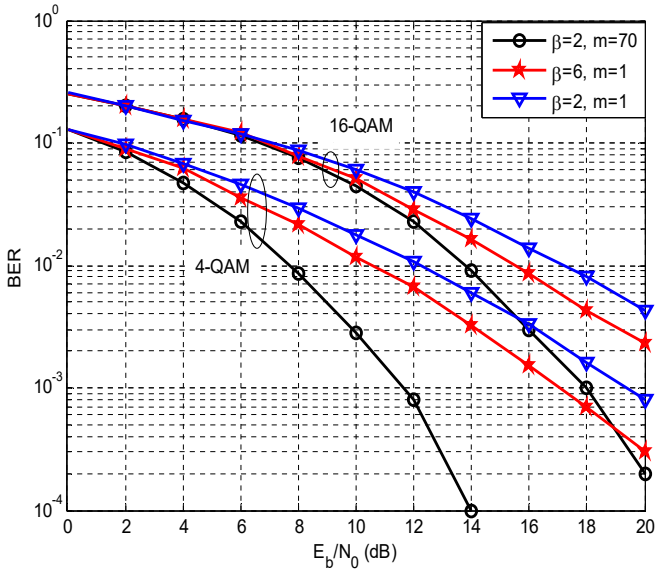

Fig. 8 BER of MIMO-OSTBC system with antenna selection $L = 2$ and $N_t = 4$

The diversity order $N_t N_r$ is achieved with optimal AS, when all the entries of H are i.i.d. Gaussian distributed. Fig. 8 shows that 4-QAM outperforms that of 16-QAM by selecting 2 out of 4 transmit antennas. By increasing β from 2 to 6 approximately 5dB less SNR is required for 4-QAM compared to 16-QAM. At $\beta = 2, m = 70$, BER performance approximates the BER performance in Rayleigh fading [12].

2.4 Analyze the SM-MIMO performance in WG fading subject to AWGGN

- *Average error rate probability (ASEP) using MMSE-OSIC, ML and MMSE-OSIC^2 detection*

In sections 2.1 to 2.3, we considered AWGN noise in composite fading scenario. Here, three detection techniques mentioned in objective 1 (MMSE-OSIC, ML and MMSE-OSIC^2) are again used to improve the MIMO system performance in generalized noise scenario. Transmitted signal is modulated by 16-QAM and $\mathcal{N}$ is assumed as AWGGN noise with zero mean and variance σ^2, ($\sigma^2 = E[\mathcal{N}^2] - {m_n}^2 = \frac{N_0}{2}$, m_n is mean). The probability density function (PDF) of the AWGGN noise is described in [25]. The random variable of AWGGN distribution rigorously depends on its shaping parameter η. This distribution reveals a superior fit to the quantified noise statistics with the changing physical channel conditions and forms various noise categories as special cases of AWGGN. For $\eta = 2, 1, 0.5$ and 0, it characterizes the prominent Gaussian, Laplacian, gamma and impulsive noise respectively. k denotes fading figure where $0.5 \leq k < \infty, 0 \leq m < \infty$. The SNR γ for received symbols in the presence of AWGGN follows WG PDF, which is defined over $\gamma \in (0, \infty)$. We have considered M-QAM format for error rate analysis. The M-QAM signal constellation is formed by two independent in-phase and quadrature M-ary PAM signals, where M_I-ary PAM and M_Q-ary PAM are in-phase and quadrature signals respectively and $M = M_I M_Q$. Given that, GGD and Gaussian distribution demonstrate the identical symmetry properties.

The ASEP is obtained by averaging the conditional SEPs under slow fading conditions over the PDF of γ and it is given for rectangular ($M_I \neq M_Q$), square ($M_I = M_Q$) QAM in arbitrary WG fading with AWGGN. Consequently, it maintains substantial range of noise and fading parameters.

To evaluate the MIMO system performance, we have considered 16-QAM modulation as a function of SNR for the generalized case of noise. The quadrature-phase distance $\mathcal{D}_Q$ to in-phase decision distance $\mathcal{D}_I$ ratio is represented as $R_{ddr} = \frac{\mathcal{D}_Q}{\mathcal{D}_I}$. For this case, the average total energy per

symbol E_T is given as $E_T = 10.5\bar{\gamma}\mathcal{D}_I{}^2 + 2.5\bar{\gamma}\mathcal{D}_Q{}^2 = 0.5\left(21 + 5R_{ddr}{}^2\right)\bar{\gamma}\mathcal{D}_I{}^2$ where $\bar{\gamma} = E[\gamma]$ [26]. Taking a fixed $R_{ddr} = (10.5)^{1/2}$, the identical average energies of the in-phase and quadrature signals are obtained.

The impact of the parameter R_{ddr} is emerged to observe the system performance. When $R_{ddr} = 1$, the most favorable case occurs, this implies that the in-phase and quadrature distance are identical for both the Laplacian and Gaussian noise. For $R_{ddr} = (10.5)^{1/2}$, the same energy is obtained between the in-phase and quadrature signal thus the system performance is reduced with a small amount i.e. approximately 1dB SNR reduction for large SNRs. When the quadrature signal contains 10.5 times the average energy of the in-phase signal, for this instant loss is more essential as it gets approximately 4dB SNR loss for large SNRs, comparative to the aforementioned case where $R_{ddr} = 1$.

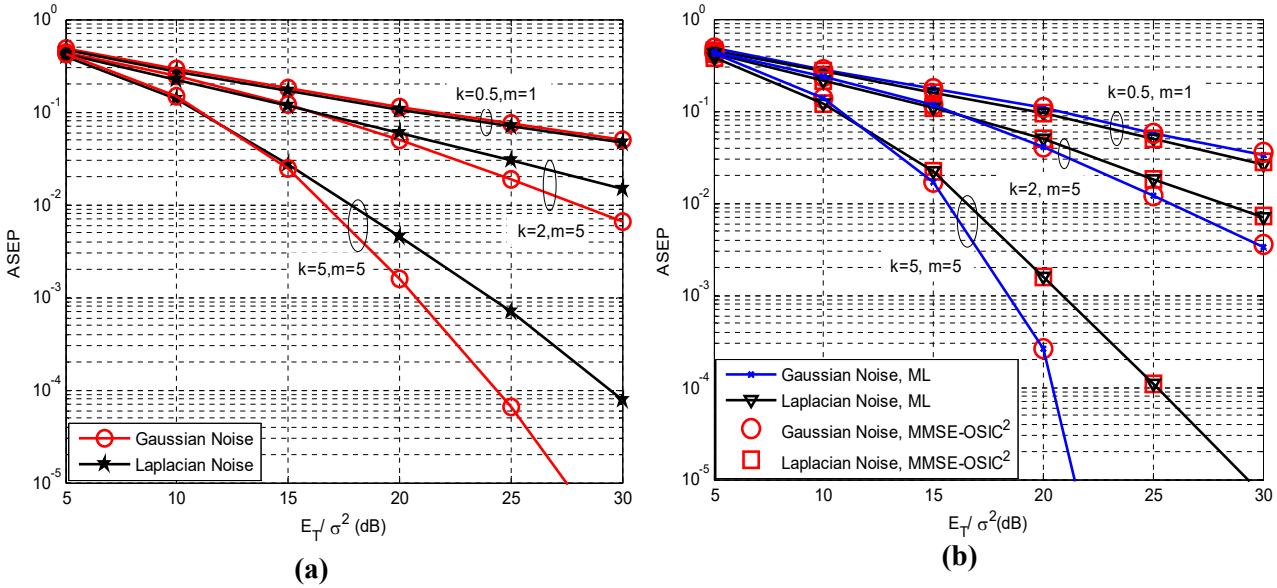

Fig. 9 ASEP of MIMO system ($N_t = N_r = 2$) over WG fading channel subject to Laplacian and Gaussian noise **(a)** MMSE-OSIC detection **(b)** ML and MMSE-OSIC^2 detection ($\mathcal{M} = 1$)

Three detection techniques are used for system performance improvement namely MMSE-OSIC, ML and MMSE-OSIC^2. We have already mentioned that the complexity level of MMSE-OSIC^2 is comparable to traditional MMSE-OSIC. Fig 9(a) and Fig. 9(b) illustrate that the error performance is highly increased using MMSE-OSIC^2 than MMSE-OSIC at high SNR whereas, the error performance is slowly increased using MMSE-OSIC^2 at low SNR. MMSE-OSIC^2 shows the approximately same ASEP as ML. Only at higher SNR (greater than 25dB), MMSE-OSIC^2 performance slightly degrades when we choose less k and m.

Fig. 9(a) and Fig. 9(b) illustrate that the ASEP performance in Laplacian noise is superior to that of Gaussian noise for lower SNR or less than 15dB SNR using OSIC detection and less than 12dB SNR using OSIC^2. However, for high SNR with less fading ($k \geq 2$), the situation is reversed, and ASEP performance improves in the Gaussian noise than Laplacian noise. For severe fading (m = 0.5), Laplacian noise offers better results than Gaussian noise.

Comparing all three detection techniques, MMSE-OSIC^2 gives the superior performance by managing the complexity issue with improved performance. Fig. 9(b) shows that MMSE-OSIC^2 requires approximately 2.5dB to 3dB less SNR at 10^{-3} ASEP compared to that of MMSE-OSIC.

3. CONCLUSION AND FUTURE SCOPE

In this work, we have primarily focused on the analysis of a MIMO composite WG fading using OSTBC, MRC and efficient detection techniques. The system analysis at low SNR has shown its importance, and thus, it has been taken into account in our work. We have shown that the antenna selection technique recommends for the system performance improvement and to achieve significant performance gain. Apart from composite fading, our work also considered the variation of noise. Thus, we have included such environment conditions in our work to investigate and improve the system performance.

In objective 1, a significant study of the state-of-the-art in MIMO system over a multipath and a composite fading is discussed. We have employed OSTBC and MRC for system performance comparison. MRC gives 3dB better error rate performance than OSTBC, however, OSTBC is superior in terms of computational complexity. Then, MMSE-OSIC, ML as well as less complex and approximate optimal detection technique i.e. MMSE-OSIC^2 has been offered for error rate analysis of MIMO system under WG fading scenario. Simulation results illustrate that MMSE-OSIC^2 signal detection technique gives a near-ML performance. Consequently, the complexity is comparable to MMSE-OSIC technique. Objective 2 includes the system considering the same scenario in low SNR regime. The optimal and MMSE detectors are used for system performance analysis. Antenna selection technique provides further improvement in the system performance which is mentioned as objective 3. Also, MIMO OSTBC system gives reduced error rate using 2 out of 4 transmit antenna with 4-QAM compared to 16-QAM. Our objective 4 evaluate the ASEP performance of MIMO system in composite WG fading environment subject to AWGGN using MMSE-OSIC, ML and MMSE-OSIC^2 detection. It is concluded that the ASEP performance in Laplacian noise is better than that of Gaussian noise for low SNR. However, in less fading, performance is degraded for high SNR and improved error performance is obtained in Gaussian

noise than Laplacian noise. In severe fading, improved error rate performance is achieved in the presence Laplacian noise than Gaussian noise.

The distributed-MIMO (D-MIMO) communication arises as a promising tool for achieving substantial performance gains in wireless networks. Therefore, this work can be extended by using antenna selection with transmit antenna selection (TAS)/MRC and distributed-MIMO (D-MIMO) system. The AWGGN noise scenario can be considered in diversity scenario for the same composite model. Furthermore, multi-user MIMO and massive MIMO system performance can be analyzed in such scenario.

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